

5 What is claimed is:

~~Sub A1~~ A method of reducing a quantization distortion created by quantization of a signal by a sample-by-sample quantizer, the method comprising:

- 10 (a) detecting that the signal was previously quantized;  
(b) estimating an expected quantization distortion for the signal; and  
(c) removing the expected quantization distortion from the signal.

2. The method of claim 1 further comprising (d) determining the quantization levels for the signal.

15 3. The method of claim 2 further comprising (e) obtaining an expected quantization distortion from a distortion table for each quantization level.

20 4. The method of claim 3 further comprising (f) summing the expected quantization distortion from each of the quantization levels.

5. The method of claim 1 where the reduction of the quantization distortion is part of the pre-processing of the signal prior to encoding.

25 6. The method of claim 1 where the reduction of the quantization distortion is part of the post-processing of the signal following decoding.

~~Sub A2~~ The method of claim 1 where (c) further comprises removing the expected quantization distortion in the frequency domain.

30 8. The method of claim 1 where (c) further comprises removing the expected quantization distortion in the time domain.

35 9. A method of reducing quantization distortion created by a sample-by-sample quantizer, the method comprising:

- (a) estimating an expected quantization distortion for each of a plurality of quantization levels;

5 (b) determining the quantization levels of a frame of a previously quantized signal;

(c) summing the expected quantization distortion for the frame of the previously quantized signal; and

(d) removing the expected quantization distortion from the frame.

10 10. The method of claim 9 where (a) further comprises determining the distribution of the signal quantized to each of the quantization levels and storing the expected quantization distortion in a distortion table.

15 11. The method of claim 9 where (c) further comprises assuming a magnitude spectrum of the expected quantization distortion is flat and assuming a phase spectrum of the expected quantization distortion is the same as the signal.

20 12. The method of claim 9 further comprising (e) initially determining if a signal has been subject to quantization by the sample-by-sample quantizer.

25 13. The method of claim 12 further comprising (f) executing the remainder of the method if the signal has been subject to quantization by the sample-by-sample quantizer.

14. The method of claim 12 further comprising (f) determining a type of sample-by-sample quantization.

30 15. The method of claim 9 where (b) further comprises quantizing the signal with a sample-by-sample quantizer prior to determining the quantization levels.

16. The method of claim 9 where (d) further comprises removing the expected quantization distortion in the frequency domain.

35 17. The method of claim 9 where (d) further comprises removing the expected quantization distortion in the time domain.

18. A method of estimating quantization distortion for a frame of a signal that has been quantized using sample-by-sample quantization, the method comprising:

5 (a) determining the distribution of the signal within a plurality of quantization levels;

(b) estimating an expected quantization distortion for each of the quantization levels based on the distribution; and

10 (c) determining an expected quantization distortion for the frame as a function of the expected quantization distortion of each of the quantization levels.

19. The method of claim 18 further comprising (d) determining a spectral shape of the expected quantization distortion of the frame as a function of an error criterion used during the sample-by-sample quantization.

15 20. The method of claim 19 further comprising (e) approximating the spectral shape of the expected quantization distortion of the frame as flat.

20 21. The method of claim 18 further comprising (d) determining a phase spectrum of the expected quantization distortion of the frame.

22. The method of claim 21 further comprising (e) assuming that the phase spectrum of the expected quantization distortion of the frame is equal to the phase spectrum of the frame.

25 23. The method of claim 18 where (b) further comprises determining an upper boundary and a lower boundary for each of the quantization levels.

30 24. A method of reducing the quantization distortion created during quantization of a signal by a sample-by-sample quantizer, where a frame of the signal comprises a plurality of samples that are quantized to one of a plurality of quantization levels by the sample-by-sample quantizer, the method comprising:

(a) receiving the frame of the signal;

(b) identifying the quantization level of each of the samples;

35 (c) obtaining the expected quantization distortion of each of the samples;

(d) summing the expected quantization distortion of each of the quantization levels of the frame; and

(e) removing the sum of the expected quantization distortion from the frame.

5           25.    The method of claim 24 further comprising (f) initially determining if  
the frame was previously quantized.

10           26.    The method of claim 24 where (a) comprises receiving the signal with a  
base station.

          27.    The method of claim 24 where (a) comprises receiving the signal with a  
mobile communication device.

15           28.    The method of claim 24 where (a) comprises receiving the signal with a  
public switched telephone network.

          29.    The method of claim 24 where (a) comprises receiving the signal from a  
communication medium.

20           30.    The method of claim 24 where (a) comprises receiving the signal with a  
packet-based network.

25           31.    The method of claim 24 where (c) further comprises determining a  
distribution of the samples within the quantization levels.

          32.    The method of claim 24 where (d) further comprises determining a  
magnitude spectrum of the expected quantization distortion, and determining a phase  
spectrum of the expected quantization distortion.

30           33.    The method of claim 24 where the quantization levels are obtained from  
the signal without additional processing.

35           34.    The method of claim 24 where (b) further comprises re-quantizing the  
signal.

          35.    The method of claim 24 where (c) further comprises retrieving the  
expected quantization distortion from a distortion table.

5           36. The method of claim 24 where (e) further comprises removing the expected quantization distortion in the frequency domain.

          37. The method of claim 24 where (e) further comprises removing the expected quantization distortion in the time domain.

10           38. A distortion removal system for a frame of a signal that includes quantization distortion resulting from the frame being previously quantized to a plurality of quantization levels by a sample-by-sample quantizer, the distortion removal system comprising:

15           a distortion identification module operable to identify an expected quantization distortion for each of the quantization levels in the frame;

          a summer module operable to sum the expected quantization distortion; and

          a distortion removal module operable to remove the summed expected quantization distortion.

20           39. The distortion removal system of claim 38 further comprising an initial processing module operable to determine and provide the quantization levels to the distortion identification module.

25           40. The distortion removal system of claim 39 where the initial processing module further comprises a sensing module and a quantization module.

30           41. The distortion removal system of claim 38 where the distortion identification module comprises a distortion determination module and a distortion table.

          42. The distortion removal system of claim 38 where the distortion removal system is operable to pre-process the signal prior to encoding.

35           43. The distortion removal system of claim 38 where the distortion removal system is operable to post-process the signal following decoding.

5            44.     The distortion removal system of claim 38 where the distortion removal module is operable to remove the expected quantization distortion in the frequency domain.

45. The distortion removal system of claim 38 where the distortion removal  
10 module is operable to remove the expected quantization distortion in the time domain.

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